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ORIGINAL

HERITABILITY OF MOTOR SKILLS: STUDY WITH MONOZYGOTIC AND DIZYGOTIC TWINS

HEREDABILIDAD DE LAS CAPACIDADES MOTORAS: ESTUDIO CON GEMELOS MONOCIGÓTICOS Y DICIGÓTICOS

Costa de Sousa, E.[1]; Vasconcelos de Oliveira Borges, M; Pereira do Rego, J.T.[3]; Alonso, L.[4]; Sierra Sánchez, D.[5] y Moreira Silva Dantas, P.[6]

[1] Mestre em Ciencias da Saúde, Universidade Federal do Rio Grande do Norte, Brasil, e-mail: elyscosta@hotmail.com
[2] Mestre em Educação Física, Universidade Federal do Rio Grande do Norte, Brasil, e-mail: vasmichelle@gmail.com
[3] Mestre em Educação Física, Universidade Federal do Rio Grande do Norte, Brasil, e-mail: jtafarel@hotmail.com
[4] Graduado en Ciencias de la Actividad Física y el Deporte - Universidad Católica de Murcia, Espanha, e-mail: daniel.sierra.san@gmail.com
[5] Professor Doutor da Universidade Federal do Rio de Janeiro, Brasil, e-mail: alonso.lvs@gmail.com
[6] Professor Doutor da Universidade Federal do Rio Grande do Norte, Brasil, e-mail: pgdantas@terra.com.br

Spanish-English translators: Víctor Gutiérrez Martínez, Jesús Villar, e-mail:victor@idiomasleon.es, Centro de estúdios Idiomas León.

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ABSTRACT

The aim of the study was to assess the relative power of genetic and environmental contributions to the variation of motor skills in monozygotic and dizygotic twins. Method: For this study, participated 88 people divided in 56 monozygotic and 32 dizygotic twins of both sexes. For the assessment the flexibility, was performed hip flexion test, for assessment the lower limb power, was applied the test against movement and the speed of movement, the 30m running test. To determine the index of heritability, was used an equation: $(h^2) = (S^2MZ - S^2DZ) / S^2DZ x100$. For the statistic, was used the descriptive treatment and Shapiro-Wilk test. The variance values were calculated, through the tendency central values. Data were categorized into percentiles of 25%. Results: Flexibility was 16% by heritability influence, speed of movement 83% of influence and for the lower limbs power were 70%. Conclusion: In this study was demonstrated higher heritability for the variables of lower limbs power and the speed of movement, and for the flexibility, a greater influence was linked for environmental factors.

KEYWORDS: phenotype, genotype, muscle strength, running, heredity.

RESUMEN

*E*l objetivo del estudio fue evaluar el poder relativo de contribución genética y ambiental de la variación de capacidades motoras en gemelos monocigóticos y dicigóticos. *Método:* participado 88 sujetos divididos en 56 monocigóticos y 32 dicigóticos de ambos sexos. Para la evaluación de la flexibilidad fue realizado el test de flexión de cadera; para la potencia de miembros inferiores fue aplicado el test contra movimiento y para la velocidad de desplazamiento, el test de carrera de 30m. Para determinar el índice de heredabilidad, utilizamos la ecuación: $(h^2) = (S^2DZ–S^2MZ)/S^2DZx100$. Fue utilizado tratamiento descriptivo y el test Shapiro-Wilk. Con la varianza de datos fueron calculados valores de tendencia central. Los datos fueron categorizados en percentiles de 25%. *Resultados:* flexibilidad 16%, velocidad de desplazamiento 83% y potencia de los miembros inferiores 70%.*Conclusión:* Fue evidenciado mayor heredabilidad para las variables de potencia y velocidad, y mayor influencia ambiental para la flexibilidad.

PALABRAS CLAVE: fenotipo, genotipo, fuerza muscular, carrera, herencia.

INTRODUCTION

The study of twins is used in different research areas of human genetics and it has the purpose of knowing the relative influence of genotype and environment on phenotypic variance, based on the variation (greater or minor) observed in pairs of monozygotic (MZ) and dizygotic (DZ) twins.

The use of a method based on twins demands the observation of several premises, knowing that twins are a sample of the general population, and the components of each pair of twins are subject to the same influences of environment (Beiguelman, 1994) .

The environment acts in the same way over the elements of the population, regardless of the fact that they are twins, leading to intrapair phenotypic differences for both MZ and DZ (Beiguelman., 1994; Thomis et al, 1997). Thus, an important source through the twins method guarantees the same shared environment among them. Meanwhile, genetic analysis in studies using a more rigorous and sophisticated model showed identical results to studies using the classical method of research with twins (Beiguelman., 1994; Maes et al, 1996).

Understanding genotypic and phenotypic influence on motor skills may be an essential criterion for improving the practice guidance of a physical activity that is adequate to the individual and collective characteristics. The literature notes what motor skills are components of performance and, thus, essential training program contents. Such capabilities are considered the basis of a hypothetical pyramid that consists of all components of the performance, such as flexibility, strength and speed (Benitez Sillero, Silva-Grigoletto, Muñoz Herrera, Morente Montero, and Guillén del Castillo, 2015; Marques & Oliveira, 2001).

What is now proposed is to indicate the need to investigate motor skills on the perspective of hereditary influence. Therefore, the objective of this study focuses on assessing the relative power of genetic and environmental contribution to the variation of motor skills in monozygotic (MZ) and dizygotic (DZ).

MATERIAL AND METHOD

Pairs of monozygotic and dizygotic twins, residents of the metropolitan region of Natal (Natal, Panamirim and San Gonzalo de Amarante) - Rio Grande do Norte – Brazil, were the participants of this study. The sample was composed by 88 subjects, 56 monozygotic and 32 dizygotic, from 8 to 36 years of both genders.

In order to understand the effects of time on the results of heritability, we opted for our study for a wide range of age. We understand that this age range may interfere with the results of h^2; however, by understanding that extreme values are overridden by their correlations in the opposite end, we took the decision of using a wide age range. And for higher security on our findings we used the confidence interval (CI) from 25% to 75% in an attempt to eliminate this trend to the greatest extent.

The selection of twin pairs was carried out in a non-intentional probabilistic way. The term of free and informed consent (TFIC) was signed by participants over 18 and for children, parents or legal guardians.

We applied an anamnesis to analyze the health and lifestyle habits related to physical activity, and a physical activity questionnaire PAR-Q to analyze if they are ready to perform physical activities. It was answered by those under 18 with help parents or legal guardians.

The determination of zygosity received special attention. It followed some steps and procedures and it was done with the following procedure: zygosity questionnaire applied to mothers by telephone, validated by Peeters (Alonso, Souza Oliveira Nascimento & Dantas , 2014; H. Peeters, Van Gestel, Vlietinck, Derom, & Derom, 1998), who recommends that it can only be answered by the mothers of each pair of twins.

Followed the above, we proceeded to observe the similarity of physical characteristics between pairs of twins (skin color, eye color and hair, hair type, format nose, mouth and teeth, height and body mass) (EC Bouchard, Shephard, & Stephens, 1994), we observed difference criteria to confirm whether the pair is MZ or not.

If there was a major difference in physical features (skin color, eye color and hair, hair type, nose format, mouth and teeth), the MZ pair, found in the questionnaire before, is removed from the sample. If there is a difference of more than 5 cm in height and 5 kg in body mass, the MZ pair found in the questionnaire before was removed from the sample.

Besides this, a self-assessment of pubertal stage was carried out for couples up to 19 years old since it is understood that from that age, the individual is already matured (Junior & Campos Lopez, 2010). This was verified by a self-assessment protocol using Tanner´s table (Tanner, 1981), in an isolated room, ie, in a room where there were only an evaluator and a participant, with the presence of a person in charge.

Carriers of physical deficiency that prevents the assessments of muscle strength, flexibility or speed; pregnant women, people in medical treatment related to obesity and carriers of endogenous or secondary obesity (Down syndrome, Prader Willi, hypothyroidism, etc.) were excluded from the study. They were also excluded from the investigation those pairs of twins of different gender, and pairs who do not share the same environment and same physical activity habits.

For the self-assessment of the pubertal stage the phase difference was established as the cutoff for the exclusion of the pair of twins. Therefore two measures were taken: the first after the preliminary interviews and the second after the physical assessments. Thus, it was possible to calculate the weighted Kappa index between the repeated measures of self-assessment of the pubertal stage, separately for monozygotic (MZ) and dizygotic (DZ) individuals, which values above 0.890 with $p < 0.001$ were found. In case there was an intrapair difference of the twins to the outcome of pubertal stage, this will be removed from the analysis.

The twins were assessed with a maximum interval of 60 minutes between one person and another, to avoid possible effects of environment on the results of the tests. No subject participated in any strenuous activity or consumed alcohol or caffeine for 24 hours before the completion of the tests.

This study was approved by the Research Ethics Committee of the University Hospital Onofre Lopes - CEP/HUOL, duly recognized by the National Commission of Research Ethics on the 484/10 protocol, according to Resolution CNS 196/96, according to the Declaration of Helsinki from 1975 and the treaty from 2000.

Instruments

We used an electronic balance Filizola® 110, with capacity to 150kg, with unit of measure 0.1 kg. to measure body mass. Height was obtained by using a Sanny® stadiometer, with unit of measure 0.1 cm. The angular position of hip flexibility during testing protocol was recorded by means of an electronic goniometer Miotec®, with a sampling rate of 2000 Hz®.

Data were recorded in the Miograph® software, version 2.0. The test of power in the lower limbs was assessed with the CEFISE® jumps tapestry and data was recorded in the Jump System 1.0 software. For speed we used electrical photo cells CEFISE®, Speed Test Fit model with accuracy equal to 0,001s.

Evaluation of flexibility

To verify the degree of flexibility, the person evaluated was oriented in a supine position and without heating or pre-stretch he had to perform the same movement of hip flexion three times, with one-minute interval between each movement, as Figure 1.

The angular positions of hip flexibility during the evaluation protocol were recorded by means of an electronic goniometer Miotec® with a sample rate of 2000 Hz. The data were recorded in the Miograph software, version 2.0. Three assessors were needed for this test they. The first assessor was responsible for the passive stretch in the right leg of the person evaluated, so that with one hand could hold the region of the malleolus and with the other hand the knee, in order to avoid any possible bending and always taking into account the speed of movement and maintaining verbal contact with the person evaluated. The second assessor was responsible for setting the goniometer in the region of the hip joint and following the stretching. The base was the osseous marking of the lateral epicondyle of the fêmur and setting the angle; the third assessor is responsible for reading the angle reached. In this test, the left leg is set for a safer stabilization and thus prevent rotation of the pelvis (Sullivan, Dejulia, & Worrell, 1992).

The stretch ceiling and therefore the verified angle is based on the feeling of discomfort and pain (Branco et al, 2006; Sullivan et al, 1992). During the implementation of the measures, the person evaluated was instructed to remain in the end position of motion for 3 seconds which was the necessary period for the third assessor to verify the highest angulation. The highest value obtained in the 3 measurements was adopted as the reference value (Cyrino et al., 2004). This was updated into the software for further analysis.

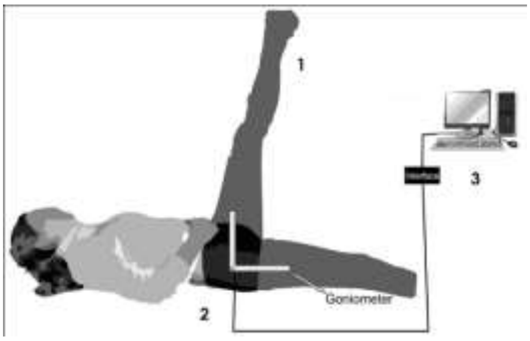

Figure 1. Schematic model of the hip flexibility test with electronic goniometer

Evaluation of the power of lower limbs

The test of power in the lower limbs was made through Counter Movement Jump (Figure 2), with the CEFISE® tapestry Contact. The results were analyzed by the Jump System software, version 1.0. The measure used was the jump height in centimeters.

Prior to the application of the test the people evaluated were guided to make a general warming for 5 minutes, static stretching of quadriceps and hamstrings for 15 seconds for each move.

The person evaluated performed four jumps with maximum strength, with an interval of 60 seconds between them. He positioned himself on the mat in a standing position (position 1), and when he was authorized by the assessor he had to perform the jump plus squat to boost his knee joint up to 90 ° (position 2).

The hands remain fixed in the hip, in the region of the iliac crest, and the feet were positioned parallel to the width of the waist. From this position, the subject performed a possible vertical jump as high as he could and tried to maintain the verticality of the trunk and legs straight in the air (position 3). For damping the fall (position 4), the evaluated people may bend their knees whereas during the aerial phase they should keep them extended. In case they bended their knees before the authorization of the evaluator, the jump was considered invalid and they had to repeat the sequence of jumps (Sousa et al., 2013). We used the highest value among the 4 jumps.

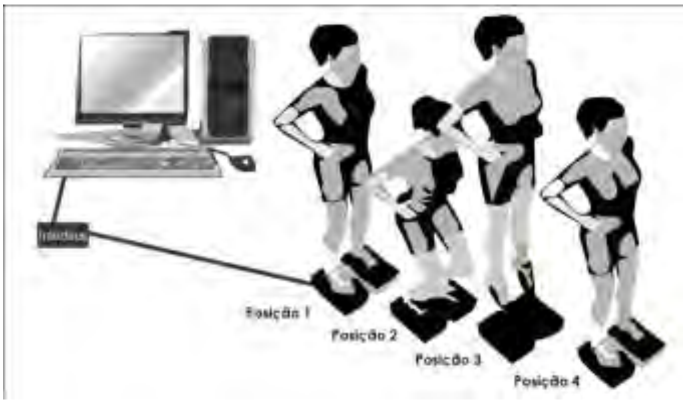

Figure 2. Schematic model of the sequence of jumps for the test of lower limbs power.

Evaluation of the travel speed

The travel speed was evaluated by using CEFISE® photo electric cells, Speed Test Fit model whose accuracy is equal to thousandths per second. The running test of 30 meters was applied, with cells positioned in the marked limbs. We used two barriers of cells located at 0m and 30m of the path and positioned approximately at the waist height of the person evaluated.

The race start was from a standing position behind the first photocell barrier. The person evaluated covered the distance of 30 meters in the shortest possible time, without slowing down before surpass the last barrier of photocells. (Coelho et al., 2010). The test was conducted 3 times for each individual with an interval of 2 minutes between them. We used the least value among the 3 measurements for the calculation of the intrapair variance.

Statistic analysis

Statistical analysis was made based on the twins intrapair variance. As a strategy for observing normal data, we used classic criteria to verify the normality of the sample: asymmetry behavior (two times lower than the standard error of asymmetry), kurtosis (two times lower than the standard error of kurtosis), and the minimum and maximum values of the mean (which must be within the value of three times the average).

Since these premises were not met to affirm the normal distribution, all data analysis was obtained through non-parametric statistics. We initially calculated the median and its respective IC (25-75 percentile) through a test of 2 independent samples.

We also calculated the Kappa index weighted between repeated measures of self-assessment of the pubertal stage, separately for monozygotic (MZ) and dizygotic individuals (DZ), in which we found values above 0.890 with $p<0.001$. For that, we applied twice the self-assessment of the pubertal stage, one after the preliminary interviews and another after the physical assessments. In case of twins intrapair difference to the outcome of the pubertal stage we removed from the analysis the data of that particular pair.

Besides that we calculated the inheritance rates of all variables of this study and showed how much of genotypic and phenotypic character every variable has. For quantitative variation characters, we took the differences between MZ and DZ pairs of twins pairs and used the following equation (Clark, 1956): $h^2 = ((S^2\ DZ - S^2\ MZ) / S^2\ DZ)$? X100. S^2 represents the median of the variance of each series of differences. When $h^2 = 1$ (100%), the variance of character is attributable solely to hereditary causes

When $h^2 = 0$, the variation is entirely explained by environmental effects. In both cases, we assume that the measurement errors are random and tend therefore to be annulled. h^2 will be presented in percentage.

In the absence of a specific classification regarding the power of genotypic contribution of motor skills, our study involves a classification.

In this classification we can observe a subdivision, as inferential statistics, where data were categorized into quartiles of 25% to 25%. These ponderate the inheritance of the aforementioned capabilities and the lower quartile below 25% is referred to low heritability, from 25,01% to 50% is considered to be low-moderate, from 50.01% to 75% is high-moderate and over 75% is considered to be high heritability (Oliveira et al, 2014;. Sousa et al, 2013.).

RESULTS

Table 1. Descriptive statistics of body mass and height of the twins studied.

Zygosity	Body Mass Twin A (kg)	Body Mass Twin B (kg)	Height Twin A (cm)	Height Twin B (cm)
Monozygotic	48,7 (14,77)	49,4 (15,80)	1,5 (0,14)	1,5 (0,14)
Dizygotic	54,0 (24,03)	53,1 (23,81)	1,6 (0,20)	1,6 (0,21)

Table 2. Variance of heritability and physical capabilities in monozygotic and dizygotic twins.

Zygosity	Jump Height Variance	Speed Shift Variance	Flexibility Variance
Monozygotic	1,978636	,013512	78,036190
Dizygotic	6,531875	,078041	92,514063
H^2	70%	83%	16%

H^2= Heritability Index.

Table 3. Heritage effect on physical features.

Feature	Heritage effect
Flexibility	Low
Jump Height	High-moderate
Speed shift	High

Classification: < 26% = Low; 26% – 50% = Low-moderate; 51% – 75% = High-moderate; > 75% = High.

DISCUSSION

The heritability estimate for flexibility was low according to the classification, which foretells a stronger environmental contribution. These results corroborate the findings of Bouchard et al(1997) who found an estimated heritability of 18% for the sitting and raising test in twins of both genders and ages between 10 and 27 years. The suggested classification is low.

The level of individual flexibility tends to decrease over time and by virtue of factors such as age, sex and level of physical activity. This is also proved by the aforementioned studies and supported by the findings of Bouchard et al (C. Bouchard, 1997; C. Bouchard, Malina & Pérusse, 1997); They found that the heritability estimate regarding the waist of twins aged between 10 and 17 years was equal to 70%, which corresponds to high-moderate heritability for the classification given by the following study.

Higher heritability was found for the lower limbs power. This is high-moderate according to our classification and it aligns with the study of Maes et al. (1996) who found that the coefficient was around 65%. Peeters et al. (2005) reported that 56.4% and 62.8% of the stability of explosive strength in boys and girls respectively during adolescence is mainly caused by genetic influence and he concludes that genetic factors appear to be the main cause of stability in vertical jump height.

Similar results were found by Okuda (2005) when he stated that in his sample the heritability factor was equal to 66% which is, for our classification, high-moderate. Chatterjee e Das (1995) strengthen our findings since they say that the vital capacity, vertical jump and heart rate are influenced more by genetics than by environmental factors, which is the opposite for flexibility and agility.

As for speed shift, the heritability index according to the classification observed is considered high, which indicates a large genetic contribution. This finding runs contrary to the results of Maes et al. (1996) who found 30% of heritability for speed and the genetic contribution according to our classification was low-moderate, however, the assessed distance for this study was lower and it focused especially in measuring the shift acceleration and not the speed.

Therefore, the present study aimed to meet the rigorous evaluation criteria, both in the test applied to measure the shift speed and in the use of the method of twins, in order to minimize factors that involve preliminary results. The use of photo cells to time the test of the 30-meter race gives our findings greater accuracy and authenticity, and has been used in different studies already published (Dupont, Millet, Guinhouya, & Berthoin, 2005; Glaister et al., 2009; Lemmink, Elferink-Gemser, & Visscher, 2004; Wisløff, Castagna, Helgerud, Jones, & Hoff, 2004).

CONCLUSIONS

The relative power of genetic and environmental contribution to the variation of motor skills in monozygotic (MZ) and dizygotic (DZ) twins was evidenced in terms of higher heritability for the variables of power and speed, and greater environmental influence for flexibility. The implementation of the twin method used in this study demonstrated that individual differences in flexibility, power and shift speed of the evaluated subjects can be attributed, in part, to genetic differences, since it suggests that the flexibility of the hip joint is a feature with low inheritance in the investigated individuals.

In return, the power of the lower limbs showed high-moderate heritage which coincides with the shift speed which is a motor ability with high genetic influence according to publications.

To understand how a morph-functional variable functional is more or less influenced by heredity is of great importance for Physical Education since it is relevant for the formulation and revision of some concepts regarding sports training, motor development and the growth and development from children to the adults.

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